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Introduction

A general phenomenon experienced by almost all cities in the world has been the emergence of green and diffuse suburbs around the city centres. As a result, the population density in cities has decreased significantly. The private car has brought low density living within the reach of large groups of upper and lower middle-class families. In fact, suburbanisation of living is a consequence of various broad changes in society, such as income increase, smaller households, more leisure time, and changing housing preferences. However, suburbanisation is also usually associated with negative socio-economic and environmental impacts, including longer working and shopping trips, increased energy consumption, pollution, accidents, and problematic public transport provision (Masser *et al.*, 1992).

Suburbanisation of living was followed in subsequent years by a second wave of suburbanisation of employment. Thus, dwellings as well as jobs tended to disperse further from urban centres into wider metropolitan areas, a process which may be called extended suburbanisation or counter-urbanisation (Breheny, forthcoming).

The development of decentralised cities, as well as other trends in the economy and society, have caused an enormous increase in car use, even in urban areas. At the same time, the length of commuting trips has increased greatly. Consequently, the external costs of transport have risen drastically; according to recent calculations these may account for some 3% of Gross National Product (Verhoef, 1994).

Development in most large cities of the Western world seems to be following a more diffuse spatial pattern. In spatial planning however, a contrasting concept is gaining much popularity. This concept is embodied in the 'compact city', where housing is provided in a relatively high density form, and where jobs are concentrated in the central city and in a limited number of sub-centres. The compact city has become a leading principle in Dutch physical planning in recent

years, and is currently being adopted in Europe as an objective of urban planning (Breheny, forthcoming).

Such a compact urban spatial organisation could have major impacts on the future of transport (level of mobility, modal split). Current transport policies in many countries (especially north-western Europe) focus on stimulating public transport, and on reducing car use and travel demand, so as to reduce environmental externalities and congestion. The compact city could be successful in supporting collective modes of transport and reducing urban travel demand. At the same time however, it should be noted that the compact city concept has some intrinsic limitations in terms of quality of life, land use and prices, and congestion; and furthermore, many other factors (level of well-being, telecommunications) impinge on the future of transport and the introduction of new transport technologies.

In this chapter we will investigate how far a compact city might contribute to the achievement of more environmentally sustainable transport by the so-called collectivisation of the transport system. Another advantage of the compact city could be the reduction of travel distances (Organisation for Economic Co-operation and Development, 1995); however, we will not discuss this possibility explicitly here.

The structure of the chapter is as follows: first, we will analyse the extent to which collectivisation of transport could contribute to a reduction in externalities; next, the theoretical relationship between transport and urban form will be discussed; we will then identify other strategic factors which influence the collectivisation of urban transport; from this we will turn to some empirical research on the compact city, by presenting the results of a questionnaire survey of Dutch transportation experts on the feasibility of new transport systems; and finally, we will draw some conclusions.

Sustainability and the collectivisation of transport

As discussed above, transport policy in many countries is focusing on the reduction of the external costs of transport by stimulating a modal shift from the private car to public transport (see for example, ECMT and OECD, 1995). It seems to be a legitimate question to ask how far collective modes are more sustainable. One of the main advantages of public modes is that they are more energy efficient than the private car, which results in lower emissions of harmful gases, like CO_2, and also of gases which cause smog (see Table 1).

Table 1. Modal comparison of CO_2 emissions in grams/pass.km. (index).
Source: Netherlands Railways (NS)

Passenger train	Car	Tram metro	Bus
71	201	100	159

Note: These figures should be used with care, as the uncertainty margin may be up to 25% or more, depending on the assumptions regarding seat occupancy, technology used, vehicle use etc.

Most collective transport modes are powered by electricity. For future emission reductions therefore, the way electricity is produced in the next decades is important. For example, when coal is used, CO_2 emissions may not be reduced significantly, but when solar or wind energy, biofuel, or nuclear generation is used, the emissions may be reduced much further (the latter, of course, has other negative impacts on the environment).

But there are also other advantages from a modal shift (Vleugel, 1995):

- the use of space is more efficient (or the capacity of the infrastructure is larger), which may be especially important in a compact city in which there is little space
- collective modes produce a smaller amount of solid waste, partly because of the long lifetime of vehicles
- collective modes are safer and have fewer social costs
- there is less noise and air pollution because of the use of electricity instead of fossil fuels - this advantage is especially important in urban areas

It may be concluded that the collectivisation of transport could offer an important contribution to the achievement of sustainability goals. However, policies to encourage this are fraught with a variety of problems, which may emerge in several fields. Firstly, therefore, we will discuss the relationship between urban form and transport, and then we will investigate other factors which are important in influencing transport sustainability.

Transport and urban form

Existing locations (of residences, industries, public services, recreational areas and so on) determine transport needs in the short term. Consequently, land use planning, territorial planning or physical planning are important policy intervention measures in coping with transportation issues. There are some fundamental principles related to land use (Owens, 1992).

First, the quantity of space and land is limited. The use of land can to some extent be intensified by using the 'third dimension' - air and subterranean space; this option may be especially important for the compact city concept.

Second, various types of land use are not compatible with one another at short distances from each other, either because of negative external effects, or possibly because the high market price for certain specific categories of land excludes land uses with a low rate of return on investment.

And third, land use is significantly influenced by institutional measures imposed by spatial planning. In this respect European countries have different traditions. For example, the Netherlands and the United Kingdom have a relatively well-developed planning system on various spatial scales, whereas, for example, Italy and Greece have systems that enable many 'degrees of freedom'.

Regarding the objectives of spatial planning for the collectivisation of transport and reduction of transport needs, much research has focused on the relationship between urban form and passenger transport. Urban form in this context means size and density, i.e. where the interdependent workplaces and dwellings are located within the metropolitan area (see for example Banister and Watson, 1994; ECMT and OECD, 1995; Wegener, forthcoming). One of the major conclusions so far is that several higher density cities are associated with a high use of public transport and with low gasoline consumption (Newman and Kenworthy, 1989), but it should be noted that these findings cannot easily be generalised. The environmental and energy benefits of compact cities depend to a large extent on the size and structure of incoming and outgoing commuting flows, as well as on the location of workplaces; also, from an economic perspective, changes in land prices ought to be considered: therefore an unambiguous answer is often

impossible.

A powerful barrier to the adoption of a new transport technology appears to be the spatial inertia of the built environment and of infrastructure networks. Artefacts following from land use, such as housing blocks, industrial estates and transport infrastructure, have a long life-cycle in relation to the capital investment involved. As a result, different types of land use are fixed for a number of decades. So, once the infrastructure is built, it will be there for a long period (especially in historical city areas). As a consequence, technologies which imply step by step (incremental) or small-scale change may have a better chance of adoption in the urban territory than technologies implying radical change of infrastructure and land use.

Other factors influencing urban transport

Although the intricate relationship between transport and spatial organisation is widely recognised, other driving factors that are critical for the future of the urban transport system may also be distinguished (Rienstra *et al.*, forthcoming). In this section we will briefly outline such factors.

Economic and institutional factors

In recent years a marked shift in emphasis towards economic principles can be observed for combined transportation, environment and spatial policy. In spatial planning a trend in favour of abolishing planning systems can be found, because government intervention is considered to be less effective and less acceptable in society (Fokkema and Nijkamp, 1994). Due to the trends discussed earlier however, it is questionable whether the compact city could come into existence without a strict governmental planning policy.

In transport policy various user charge principles are increasingly being discussed and implemented; these include road pricing, toll principles, parking fees and perhaps, in the long term, even tradable permits. These measures mainly affect car transport, and may stimulate the use of public transport.

However, there is also a trend to abolish unjustified and unnecessary protectionist or privileged regulations in order to increase the efficiency of transport operations. In this respect there is increasing focus on the efficiency and profitability of, for example, public urban transport companies (Nijkamp and Rienstra, 1995); in many UK cities the public bus companies have been privatised, which has had an enormous impact on the way the bus network is operated. In this way the profitability of links and of the total network - and as a result, spatial threshold factors - of public transport modes have become more important. These factors are concerned with the minimum volume of passengers, between given points, that are necessary for a collective transport mode to be in operation and for it to be feasible from an economic perspective. In this respect, barriers to adoption arise when spatial threshold (minimum) levels of demand for collective modes are not reached, for example, due to a low population density. Spatial upper level factors are different, in that they are associated with a particular type of vehicle and the maximum distance it can bridge. Barriers may arise when the transport distance needed exceeds the critical upper level of the spatial range of the transport mode in question.

A major disadvantage of public transport in urban areas is the waiting time; because of the short distances involved, travelling time is largely dependent on

waiting times. The poor competitive position of public transport *vis-à-vis* the private car may be shown for example by figures in the Netherlands: 40% of all car trips are for distances below 5km, while this figure is only 16% for all public transport trips (calculations based on Central Bureau of Statistics, 1994). Consequently, the frequency (and reliability) of vehicles is very important to make the system competitive with the car, but for this again a high level of demand is necessary for profitability.

Another way in which collective systems may be distinguished from individual ones concerns their dependence on supplementary transport systems. Travelling by collective modes is inter-modal by nature, while individual modes offer door-to-door transport. This makes the functioning of collective modes dependent on the level of connectivity with other transport systems (including walking and cycling) that offer transport to and from the nodes. Co-ordination problems between different modes therefore may be an important factor in the failure of collective transport.

The compact city, in which voluminous transport flows occur between the compact city centre and its sub-centres, could therefore be a vital precondition if public transport modes are to be successful. However, socio-psychological factors also play an important role.

Socio-psychological factors

The private car appears to be psychologically very important, because of the pleasure, privacy, personal control and representativeness it can offer (Vlek and Michon, 1992). People may perceive the same benefits for diffuse life patterns; living conditions in compact urban areas may be considered to be worse than in more diffuse cities.

Another problem for collectivisation of transport is that the behaviour of individuals is hard to change, particularly while the disbenefits of other transport options are difficult to perceive, and while there is community resistance to the construction of large-scale infrastructure in cities with little space. Subterranean construction may be an (expensive) solution to the latter obstruction. Large-scale measures to reduce car traffic in cities may not be socially acceptable.On this point it should be added that, in democratic countries, governments will not introduce measures which contrast greatly with public opinion (Rietveld, 1995). Therefore, a change in attitude would first have to occur before the policies discussed above could successfully be introduced.

It may be concluded that a more compact city would be preferable for the collectivisation of urban transport, but that it is questionable whether such a policy could succeed, because of other factors. Therefore, it is of interest to investigate the views of transportation experts on the future of urban spatial organisation and the transport system. This will be the subject of the next section.

Expert opinions on the compact city and the future of urban transport

To investigate the future of urban transport a postal questionnaire survey was sent to Dutch transportation experts. For a detailed description and account of the questionnaire we refer to Nijkamp *et al.* (forthcoming); here we note only that the response rate was 36% (271 questionnaires), and that the response gave a representative picture of the sample. The main subject of the survey was the future of urban transport in relation to spatial organisation. In the questionnaire,

respondents were asked to indicate both expected and desired future developments in transport; this was in order to analyse the discrepancy between reality and desire, and to give the descriptive and normative opinion on future developments.

Expected and desired spatial and modal split developments

Expected spatial developments at the urban scale

At the urban level it is expected, by 44% of the respondents, that there will be moderately compact urban development, or, in other words, that the policy to achieve more compact cities will largely succeed (see Fig. 1). As a result, the trend towards 'green suburbs' will generally be halted. It is striking that only 14% expect a more diffuse spatial organisation, a proportion which is surprisingly small in view of recent trends.

Next, it is of interest to assess how the expected spatial developments are related to the modal split. Most respondents expect the modal split to change in favour of the private car, while about one third think that it will change in favour of public transport, or that no increase in car use will occur. A cross-tabulation analysis shows that only the segment which expects a development towards a compact city also thinks a shift in the modal share may occur in favour of collective modes. However, the majority expect the modal split to change in favour of the private car.

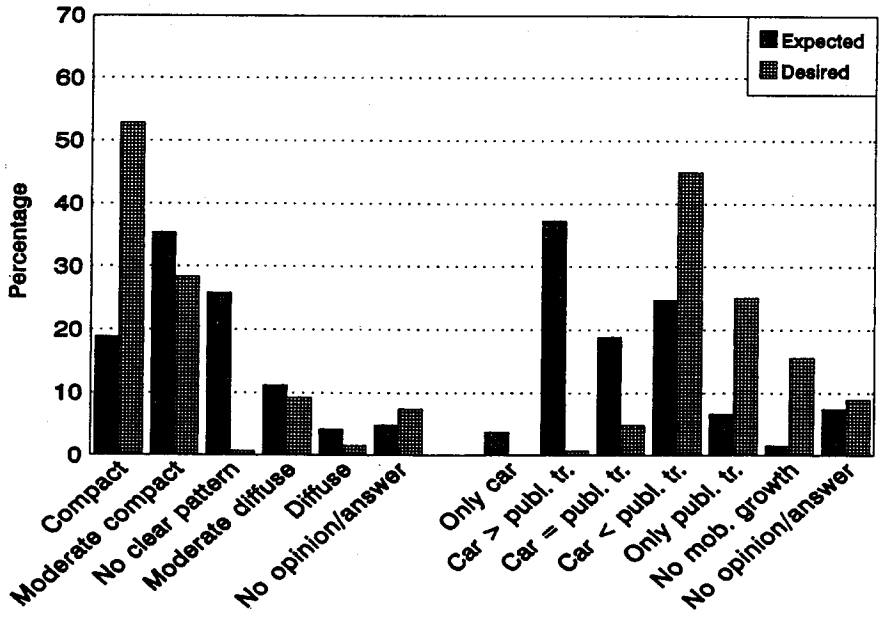

Fig. 1. The expected and desired urban spatial organisation and the resulting change in the modal split (n=271).

Desired developments at the urban scale

When the desired changes are analysed, a majority of the experts are in favour of a compact urban structure, while a large minority would wish to see a moderately compact organisation. Only a small group think that a (moderate) diffuse spatial organisation is desirable. Concerning the resulting changes in the modal split, it appears that 94% of respondents favour a shift towards public transport. Many respondents are also in support of a growth in car mobility, but a large group wish there to be no mobility growth and only growth in public transport. Cross tabulations reveal that in general the same trends as found for expected developments can be identified.

The resulting transport system

The experts were asked to give scores for expected and desired changes, on a 1 to 10 scale (a rating system which is common in the Netherlands) for policy measures, existing transport modes and the potential for new modes. The results are outlined below.

Expected and desired policy measures

The expert views on future urban transport are depicted in Fig. 2. The highest score for expected policy measures is for an increase in parking levies which may make the use of private cars less attractive. The second highest score is for a reduction of the number of parking spaces, which is expected to be introduced to a smaller extent than an increase in parking levies. Road pricing is not expected to be introduced on a large scale.

The scores for desired measures are all higher than for expected ones, although for parking levies this score is just a little higher. It is still the highest score however, with a reduction of the number of parking spaces in second place. The new technology of road pricing also gets a much higher score, so it may be concluded that experts believe this option should be introduced on a reasonable scale. As expected, the standard deviation of this measure is the highest, which means that the experts disagree most on this measure. Other policy measures which are mentioned by the respondents are: changing the spatial organisation, park and ride systems, and car sharing ('call a car').

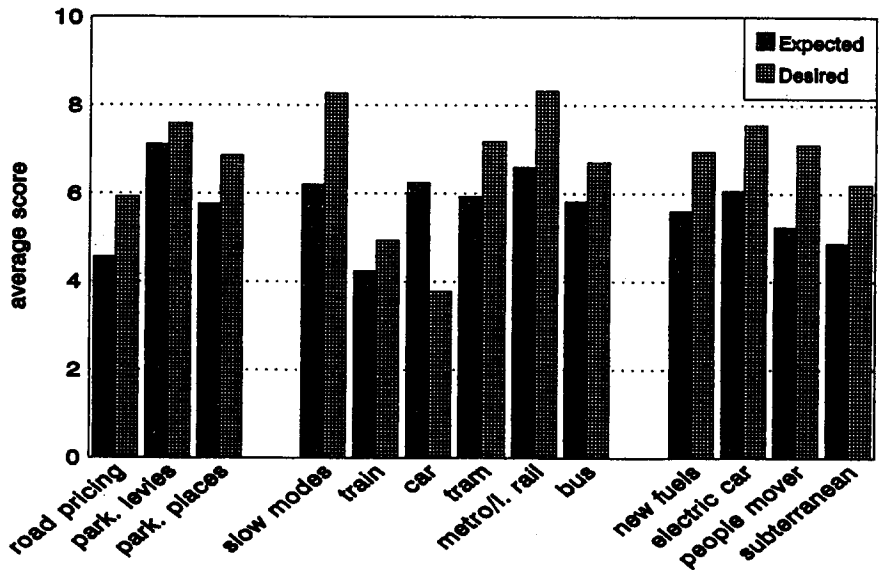

Fig. 2. The average scores on measures and modes in the urban transport system. Score 1 - 10; 1 is lowest, 10 is highest (n=254-266).

Expected and desired use of conventional modes

The scores given by the experts on the expected use of conventional modes of transport all (except for the train) fluctuate around 6. The highest score is assigned to metro and light rail systems, which are expected to be introduced on a larger scale than is the case now. This situation is fairly likely, since for example in several Dutch cities (Amsterdam, Rotterdam) new links are under construction. For the remainder, the car and slow modes (cycling, walking) are given the next highest scores, while the bus and tram get somewhat lower scores. It seems plausible that the score for the train is somewhat lower since this mode is not

primarily used for urban transport, although it is sometimes used as an urban mass transit system.

When the scores for desired changes are analysed, all modes are given higher scores, except the private car, which is plausible because of the strongly negative external effects of this mode. The slow modes and metro or light rail in particular receive very high scores of above 8, implying that the modal split in urban traffic should change in favour of these modes. Also the tram and bus receive relatively high scores, while the score for the private car is below 4; a much lower modal share is regarded as desirable for the conventional car.

Expected and desired use of new modes and technologies

Respondents were also asked to assign scores for several new technologies and modes which might be introduced before the year 2030. The highest score for expected change is found for electric cars, although this score is only about 6, which means that large-scale introduction is not expected. The second highest score is for new fuels (for example, liquid hydrogen), which implies again an improvement in the position of the private car. The people mover has a fairly low score, while subterranean transport is only expected to be introduced on a small scale. So, in summary, improvements of the private car are likely to be introduced, while other developments have far less chance of success, in the opinion of experts.

The scores for desired changes are all higher than for expected changes. Thus, the experts do not expect the introduction of new modes and technologies to happen to the extent they would like. The electric car is again awarded the highest score, followed by the people mover. In addition, somewhat higher - but nevertheless low - scores are given to the introduction of new fuels and subterranean transport by car and train. Other modes mentioned by the experts are passenger transport by water, improved human-powered vehicles and the electric bicycle.

Conclusions

From the results discussed above, it may be concluded that the private car and its improved versions are still expected to dominate the urban transport system in the future (although various policy measures may be introduced to make the car less attractive). It appears that the experts expect this to occur even though they believe that the urban spatial organisation will become more compact.

In the desired situation however, there would be a greater emphasis on collective modes, while more and severe measures would be introduced to make the car less attractive as the dominant mode. These developments would be favoured in a situation where the organisation of urban space is more compact.

Conclusions

In theory there is a clear positive relationship between concentrated spatial form and collectivisation of the transport system. In practice however, problems may occur in achieving both a more compact spatial urban pattern and a modal shift towards collective modes. For both possibilities, it is clear that current trends - like the abolition of spatial planning and the deregulation and privatisation of the public transport sector - will have to change drastically. Also, socio-psychological factors may have to change, or else it will not be feasible to introduce such changes, due to lack of support from the public.

In this respect it is interesting that most Dutch transportation experts expect compact city policies to be fairly successful. Apparently, they think the trade-off between preferable environmental conditions and living conditions will be in favour of the former. However, at the same time it is not expected that a modal shift in the urban transport system will occur to a great extent. The experts believe that only the introduction of metro or light rail systems will be significant, while the only new technology will be the electric car. If these expectations become reality, congestion in urban areas may increase greatly and most externalities will not be reduced.

In the desirable world of the Dutch transportation experts however, the compact city would be introduced, accompanied by a large-scale modal shift towards collective modes and new transport technologies. It is clear, however, that for this to happen, many current trends would have to be modified and turned in a more environmentally sustainable direction.

It is evident that a clear and consistent policy package is a *sine qua non* for collectivising urban transport. Such a package may consist of strict land use and development control policies; an increase in fuel prices; the introduction of telematics; stimulating integrated commuting strategies by employers; large-scale investment in public transport; improvements in the efficiency and attractiveness of public transport; and the stimulation of walking and cycling (see also ECMT and OECD, 1995). Such a policy package, however, may meet a lot of resistance in society and it will therefore be difficult to implement in any consistent way.

It may be concluded that policies aimed at achieving a compact city together with collectivisation of transport - which may lead to the fulfilment of sustainability criteria - are possible and even desirable. The introduction of such policies, however, will be faced with severe difficulties from all sides.

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